JPSS AEROSOL DETECTION PRODUCT

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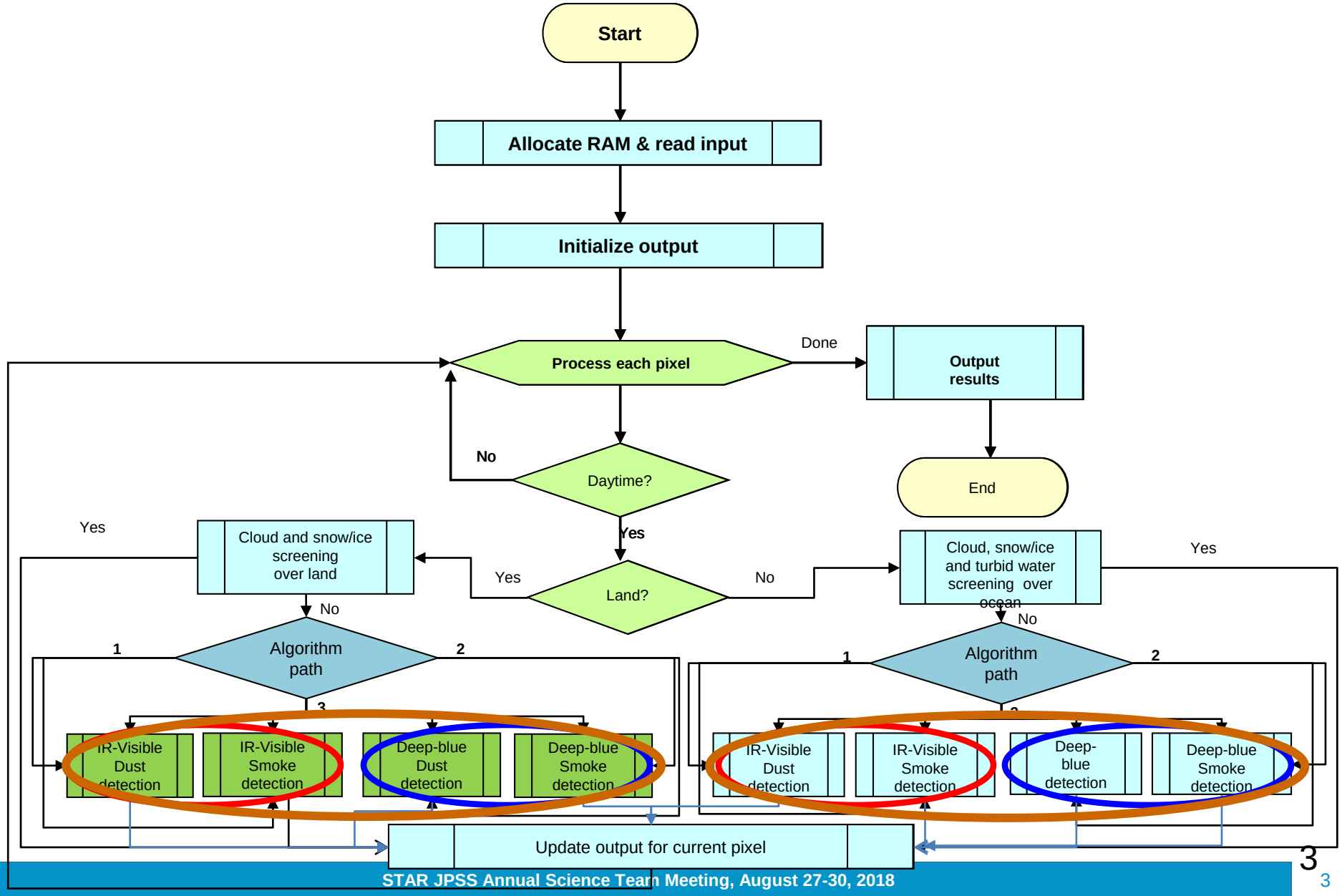
Cal/Val Team Members

Name	Organization	Major Task
Pubu Ciren	IMSG/NOAA	Aerosol Detection Product development/validation
Brent Holben	NASA/GSFC	AERONET observations for validation work
Amy Huff	PSU	User outreach and product assessment
Edward J. Hyer	NRL	Product validation, assimilation activities
Shobha Kondragunta	NOAA/NESDIS	Co-lead
Istvan Laszlo	NOAA/NESDIS	Co-lead
Hongqing Liu	IMSG/NOAA	Visualization, algorithm development, validation
Lorraine A. Remer	UMBC	Documentation and validation
Hai Zhang	IMSG/NOAA	Algorithm coding, validation within IDEA
Arthur Russakof	IMSG/NOAA	Algorithm integration
Ivan Valerio	IMSG/NOAA	Data management and user outreach

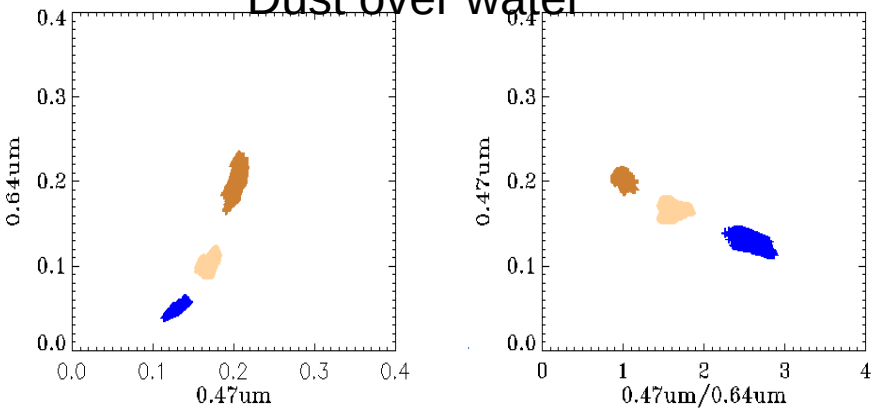
EPS Aerosol Detection Algorithm

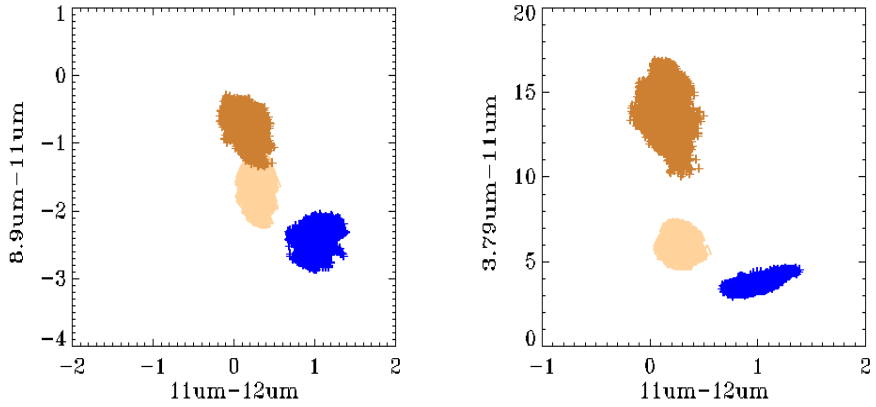


JPSS EPS Aerosol Detection Algorithm-IR-Visible path

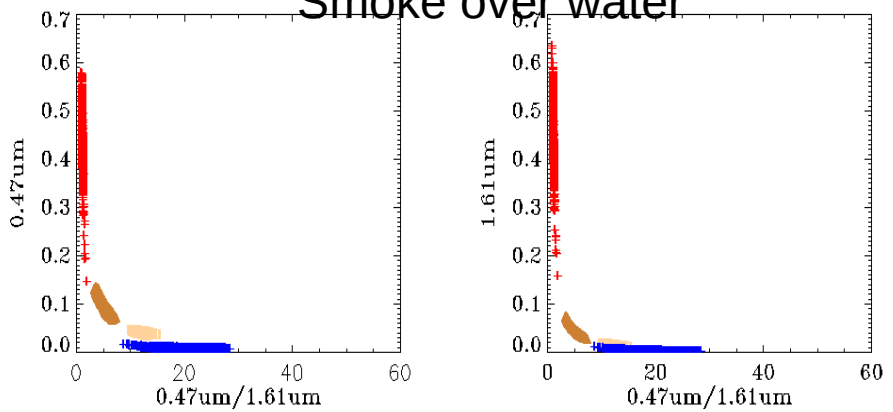
- **In IR region, dust decreases the brightness temperature difference between 11 and 12 μm, compared to clear sky. In visible region, dust reduces the contrast between two neighboring wavelengths , such as 0.47 μm/0.64 μm.**
- **Weak spectral dependence of reflection from clouds and strong wavelength dependent reflection from smoke allows us to use spectral contrast between two visible wavelengths to separate smoke from clouds; and further separate thick smoke from thin smoke .**

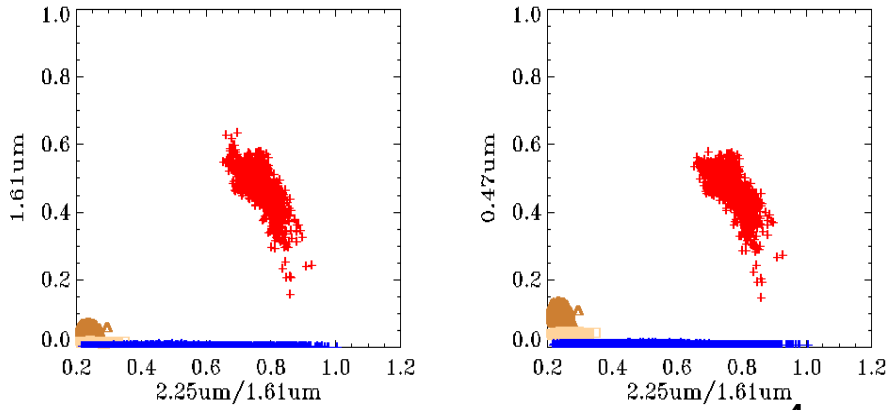
Dust over water





Smoke over water



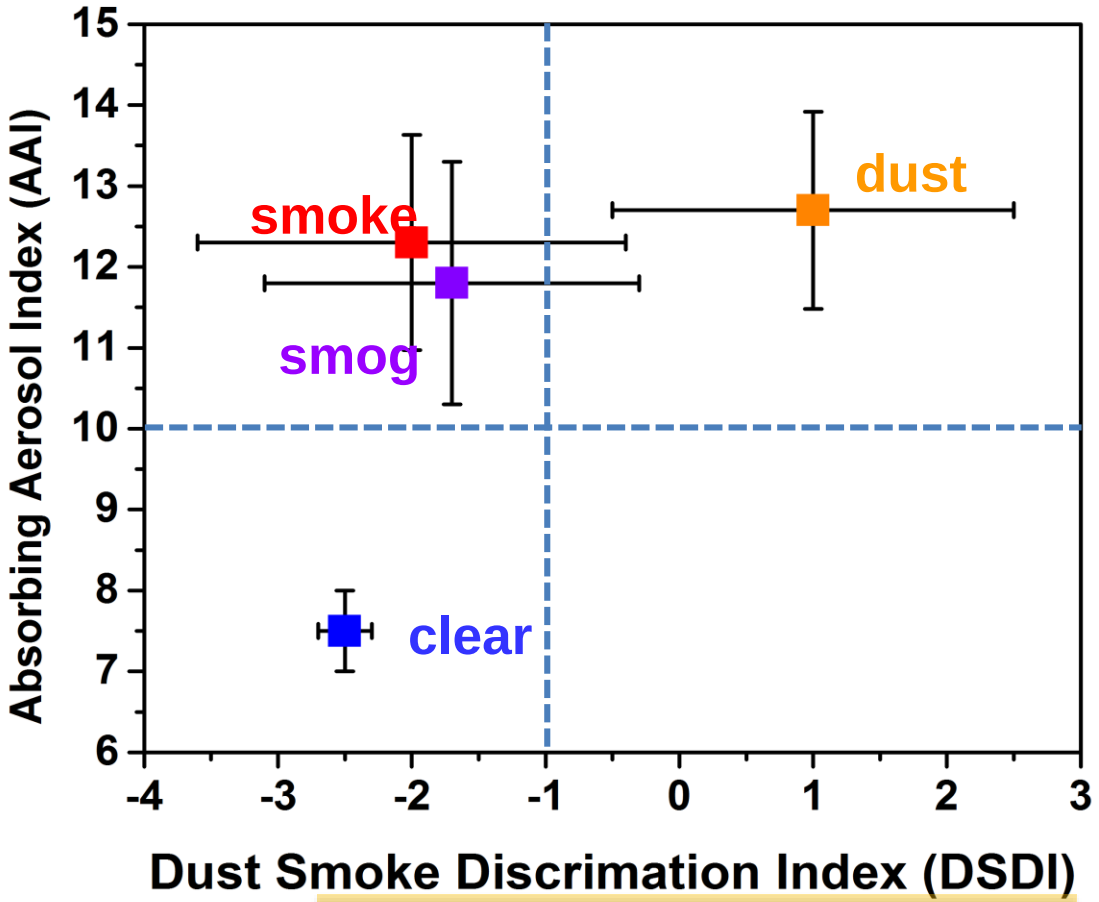


Clear | Thin Dust | Thick Dust | Clouds | Thin Smoke | Thick smoke | Clear

JPSS EPS Aerosol Detection Algorithm-Deep Blue Path

- Smoke/Dust reduces the contrast between 412 nm and 440 nm as absorption increases with decreasing wavelength.
- Difference in particle size enables us to pick-out the smoke by introducing short-wave IR channel (2.25 µm)

Absorbing Aerosol Index
$AAI = -100[\log_{10}(R_{412}/R_{440}) - \log_{10}(R'_{412}/R'_{440})]$



Aerosol indices shown here for schematic purpose only. Indices depend on view geometry

Dust Smoke Discrimination Index
$DSDI = -10[\log_{10}(R_{412}/R_{2250})]$

VIIRS Aerosol Detection Product Performance

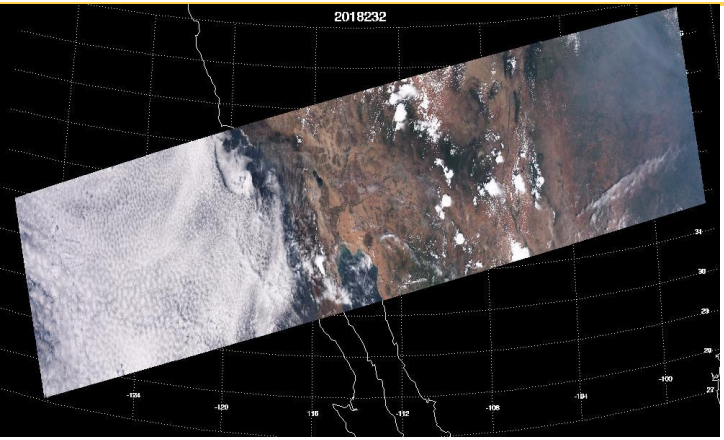
January 9 – March 31, 2018

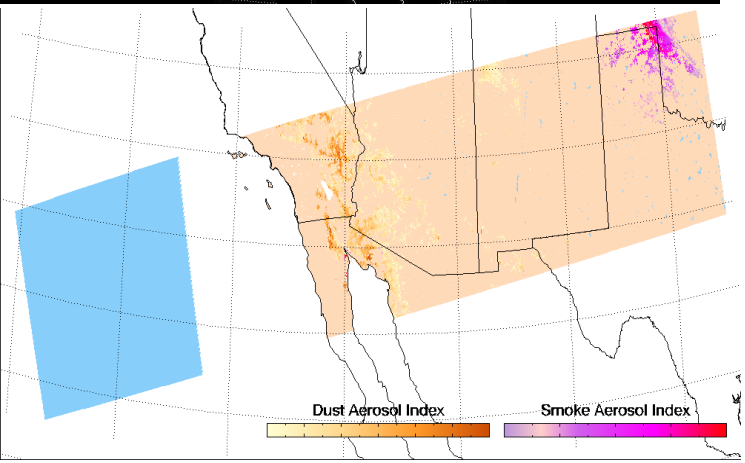
Product	L1RD APU (%)	S-NPP Performance (%)	NOAA-20 Performance (%)
Smoke	80 (land) 70 (ocean)	84.7	83.1
Dust	80 (land) 80 (ocean)	92.6	92.6

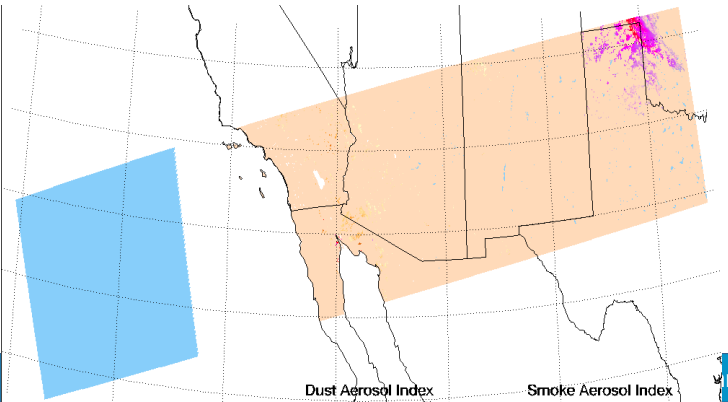
Major Risks/Issues and Mitigation

Risk/Issue	Description	Impact	Action/Mitigation
False dust detections over bright surface	Over bright surfaces such as desert, there are many false detections especially in nadir view	Product reliability issues	Developed a patch for the algorithm to revert to IR-visible path during nadir views
Missed dust detections	The full range of dust plume extent is sometimes missed due to conservative thresholds	Product reliability issues	Adjusted (relaxed) thresholds to detect dust on plume edges and so forth
Enterprise Cloud Mask	ECM assigns cloud mask to dust plumes	Product reliability issues	Not using ECM bits anymore. Using internal methods to detect clouds

ADP Improvements due to Algorithm Updates







NOAA-20 ADP Example

Relying on IR-Visible path over Deep Blue path of the algorithm minimizes false dust detections over bright surfaces when there is no dust event

FY19 Milestones and Deliverables

Task	Description	Deliverables	Scheduled Date
ADP algorithm updates	Minor adjustments to thresholds	Updated code	December 2018
Test using surface reflectance database	Test using a surface reflectance database to compute surface reflectance and remove it from reflectances before computing absorbing aerosol index and dust smoke discrimination index	Updated code	March 2019
Update STAR VIIRS aerosol website	ADP component will be added to VIIRS aerosol website	Updated website deployment	December 2018
Webinars/tutorials	Educate users about VIIRS ADP	Webinars	August 2019
NOAA-20 validated maturity review	Conduct NOAA-20 ADP validation work to demonstrate validated maturity	Review	March 2019

Future Plans/Improvements

- Algorithm Improvements
  - Maintenance
- J2 and Beyond
  - Subject to any instrument issues
- Reprocessing Plans/Status
  - Subject to availability of computing resources and SDR information
- Long Term Monitoring/Website links
  - ongoing

User Feedback & Summary

- **Smoke/Dust Mask**
  - *Group of nine air quality forecasters and others: Too many things are colored red; can't have red for high density smoke and FRP hotspots and high AOD. Suggestion to keep hot spots red but change AOD and smoke mask colors.*
  - Particulate transport
  - Good to identify what the AOD will be and help distinguish "cloud-like" features
  - Will be **very** useful when forecasting or determining smoke/fire locations
  - Much of smoke mask looks accurate, but not believable over Great Lakes on Aug 2nd. Should smoke mask more closely follow AOD?
  - The smoke and dust masks only begin to pick up smoke or dust about 45 minutes after local sunrise. The smoke and dust masks also pick up on some known bright areas, such as the Bonneville Salt Flats and urban areas like Los Angeles.
  - Needs more work
  - Looks good!
  - Still learning how this works based on western fires
  - Seems to work ok

AEROSOL OPTICAL DEPTH

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JPSS Aerosol Cal/Val Team

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Pubu Ciren	IMSG	Aerosol detection product development and validation
Amy Huff	PSU	User (forecasters) feedback, outreach
Edward J. Hyer	NRL	Product validation, assimilation activities
Shobha Kondragunta	NOAA	Co-lead (detection)
Istvan Laszlo	NOAA	Co-lead (optical depth)
Hongqing Liu	IMSG	Algorithm development, validation, visualization
Lorraine A. Remer	UMBC	Documentation, liaison to Cloud Team
Arthur Russakoff	IMSG	Algorithm integration
Ivan Valerio	IMSG	Data management and monitoring
Hai Zhang	IMSG	Algorithm coding for and maintenance of eIDEA, AerosolWatch websites

AOD/APS Algorithm Overview

- Compares selected VIS and NIR VIIRS reflectances with reflectances calculated for a set of **AOD** and aerosol models. Selects AOD and aerosol model for which calculated reflectances best match observed ones over *dark* and *bright* surfaces.
- Calculates **APS** over water as the negative slope of AODs in log-space at two pairs of wavelengths.

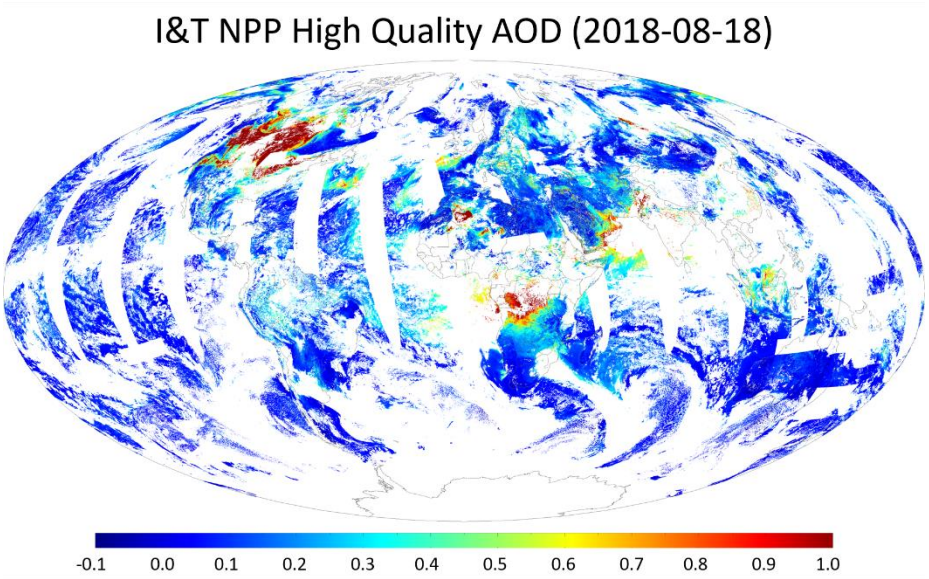
Band	Central Wavelength (μm)	Retrieval		Internal Test	
		Land	Water	Land	Water
M1	0.412	X		X	X
M2	0.445	X		X	X
M3	0.488	X		X	X
M4	0.555		X	X	X
M5	0.672	X	X	X	X
M6	0.746		X		
M7	0.865		X	X	X
M8	1.240		X	X	
M9	1.378			X	X
M10	1.610		X		X
M11	2.250	X	X	X	X
M15	10.763			X	X
M16	12.013			X	

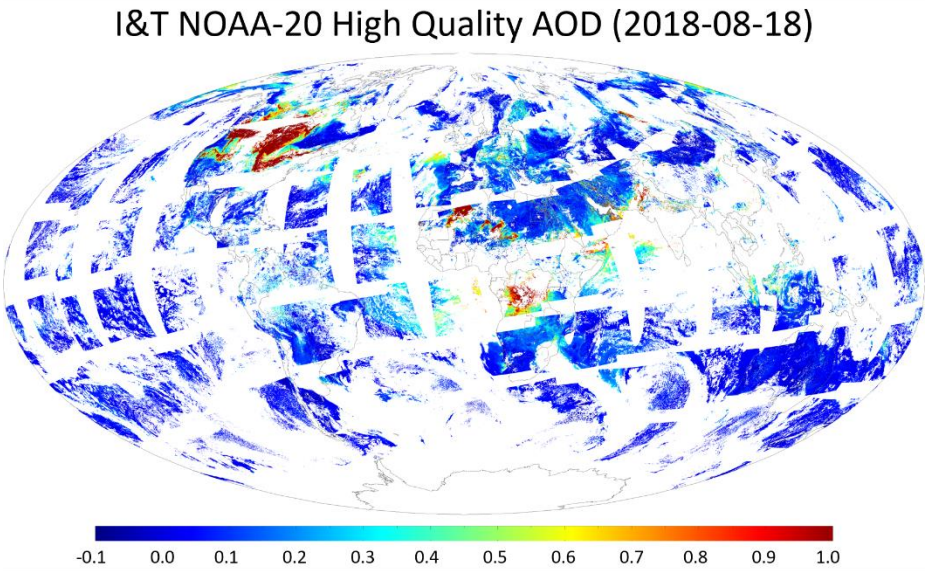
- **Input**: Reflectances in selected VIIRS bands.
- **Ancillary data**: Cloud, cloud-shadow, heavy-aerosol, land/water, snow/ice, fire and glint masks; total precipitable water and ozone amount, surface pressure, wind speed and direction; land cover type; atmospheric and sun-glint LUTs.
- **Output**: AOD at 550 nm, APS at 550-860 and 860-1610 nm; aerosol model(s), fine mode weight over water; AODs in M1-M11 VIIRS bands, diagnostic data.

S-NPP/N-20 Product(s) Overview

- **Status of AOD in NDE:**
  - **OPS**: S-NPP, JPSSRRv1.2 since 8/13/2018) (for AOD, same as v1.1)
  - **I&T**: S-NPP and NOAA-20 (with S-NPP LUT), JPSSRR v1.2
  - **DEV**: S-NPP and NOAA-20 (NOAA-20 LUT), JPSSRR v2.0; moves to I&T in Sep 2018
  - **NOAA-20 AOD is provisional pending LUT update**

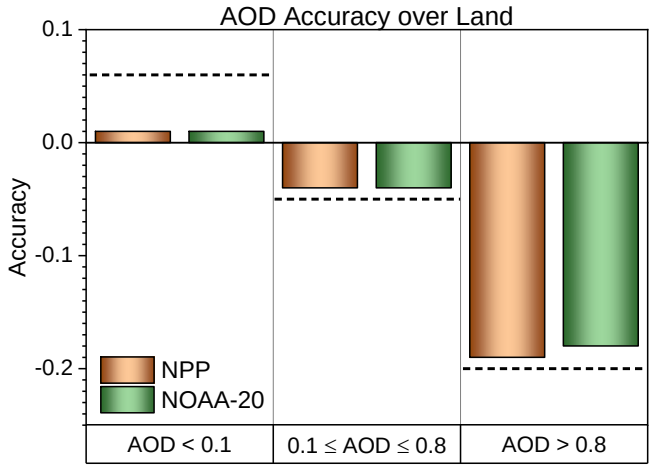
- **AOD Example** (08/18/2018)
  - S-NPP AOD in NDE OPS (still) has missing granules.
  - S-NPP AOD in OPS and in I&T are identical, but I&T has a few more granules missing.
  - NOAA-20 AOD in I&T has a lot more missing granules

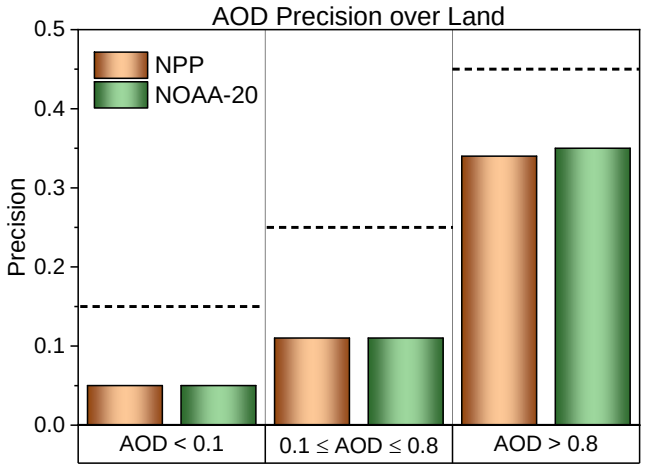




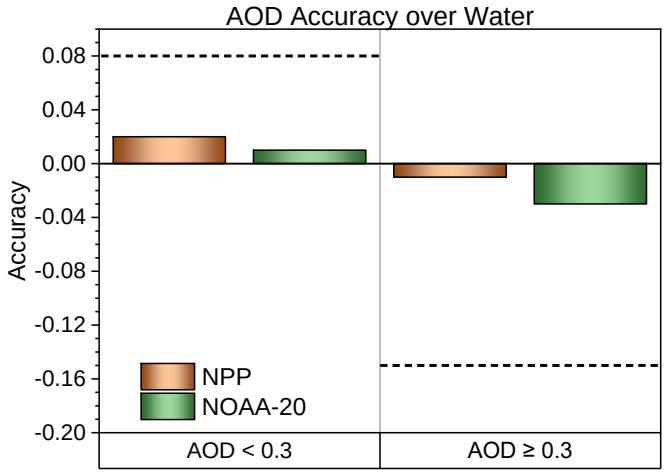
S-NPP/N-20 Product(s) Overview

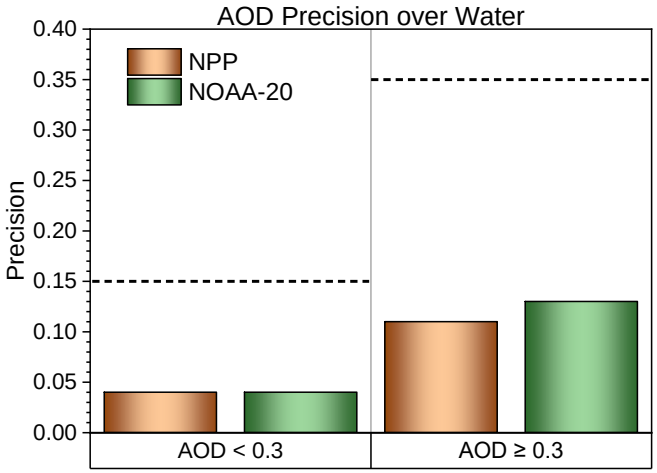
- Product(s) Performance Summary (1/7/2018 - 8/4/2018)

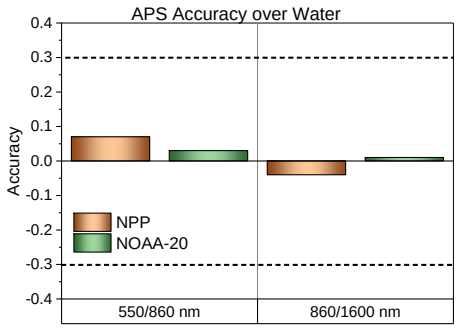


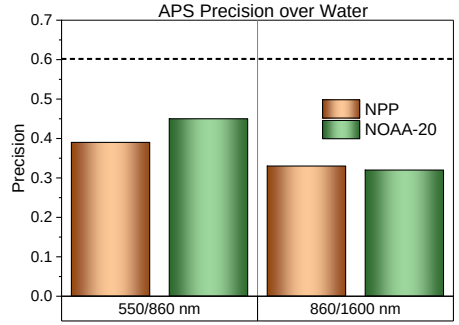


NOAA-20 results are from offline runs with NOAA-20 LUT.









S-NPP/N-20 Product(s) Overview

- Product(s) Performance Summary (1/7/2018 - 8/4/2018)

AOD	L1RDS A(P)	S-NPP	N-20
LAND			
AOD < 0.1	0.06 (0.15)	0.01 (0.05)	0.01 (0.05)
0.1 ≤ AOD ≤ 0.8	0.05 (0.25)	-0.04 (0.11)	-0.04 (0.11)
AOD > 0.8	0.20 (0.45)	-0.19 (0.34)	-0.18 (0.35)
WATER			
AOD < 0.3	0.08 (0.15)	0.02 (0.04)	0.01 (0.04)
AOD >= 0.3	0.15 (0.35)	-0.01 (0.11)	-0.03 (0.13)

APS	L1RDS A(P)	S-NPP	N-20
WATER			
550-860 nm	0.3 (0.6)	0.07 (0.39)	0.03 (0.45)
860-1610 nm	0.4 (0.6)	-0.04 (0.33)	0.01 (0.32)

Only High quality AOD and APS were used

Major Risks/Issues and Mitigation

- Provide updates for the status of the risks/actions identified

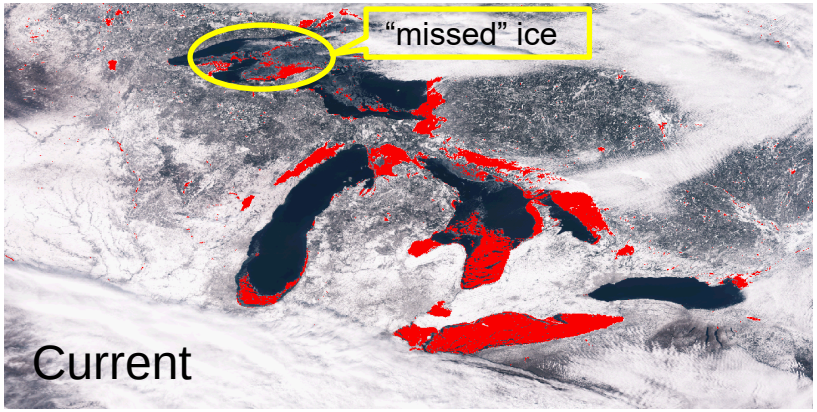
Risk/Issue	Description	Impact	Action/Mitigation
NOAA-20 LUT	Algorithm currently running in NDE I&T uses S-NPP LUTs for NOAA-20	Degraded quality AOD	Implement LUT for NOAA-20 in AOD algorithm. NOAA-20 LUT for AOD was received by NDE on 8/4/2018 and updated algorithm is currently running in DEV

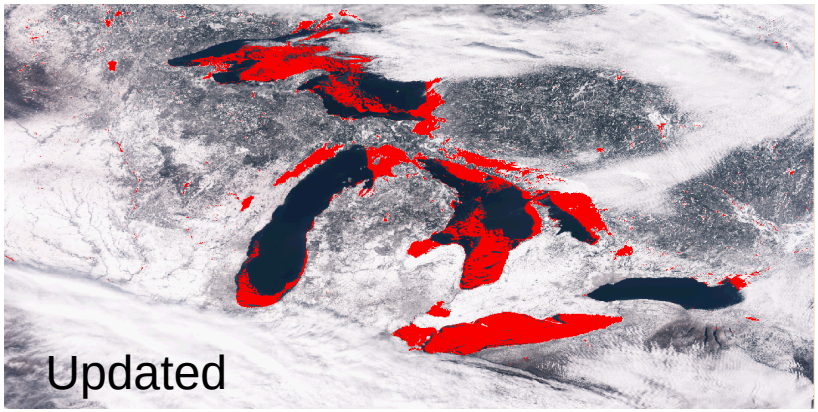
FY19 Milestones and Deliverables

Task	Description	Deliverables	Scheduled Date
Improve tracking of algorithm version	Add to the output as metadata detailed version information on algorithm and production system, internal/external data files, date and time of modifications	Updated code to ASSISTT	Oct 2018
Product maturity review	Complete NOAA-20 AOD validated maturity review	Review material	TBD
Website update	Add NOAA-20 AOD to and update the LTM site maintained by the STAR aerosol team	Updated aerosol LTM website	Dec 2018
Revise QFs	Group output quality flags based on the retrieval quality; will make interpretation easier for users	Updated code to ASSISTT	Dec 2018
Internal tests update	Sea/ice mask does not always indicate presence of ice. Revise thresholds of M4 and M7 reflectances. Cloud mask may miss heavy aerosol; update threshold.	Updated thresholds to ASSISTT	Mar 2019
AOD algorithm update	Update the bright surface reflectance database for AOD retrieval over bright surface	Updated database to ASSISTT	Jul 2019

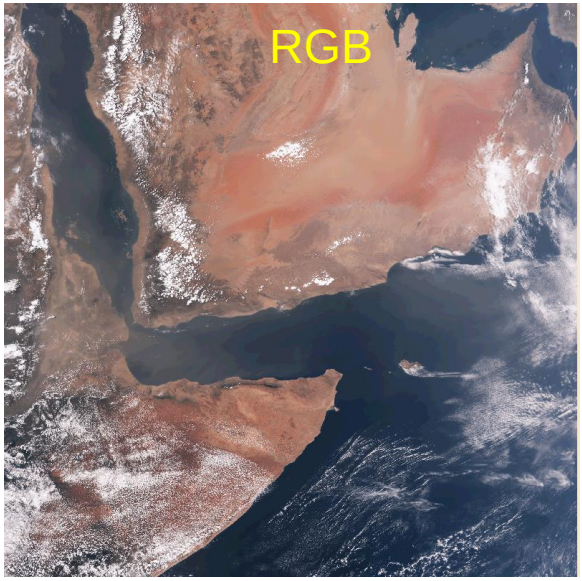
FY19 Milestones and Deliverables

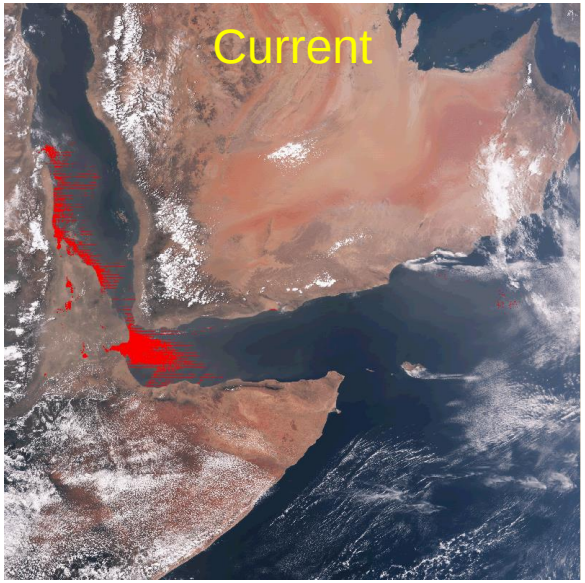
- Threshold update to better detect **ice**

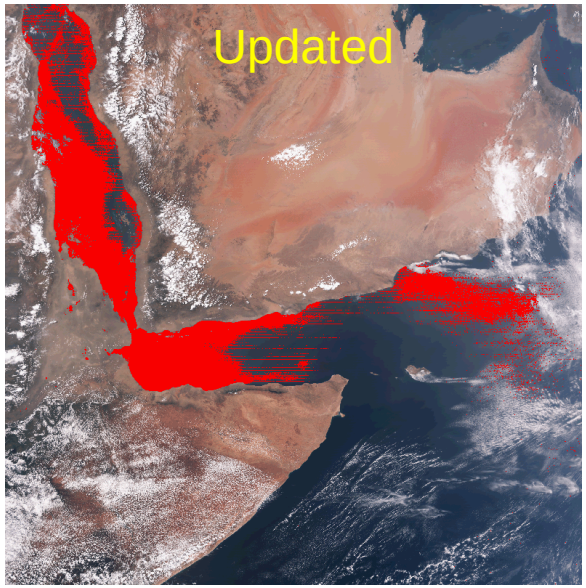




- Threshold update to better detect **heavy aerosol** over water

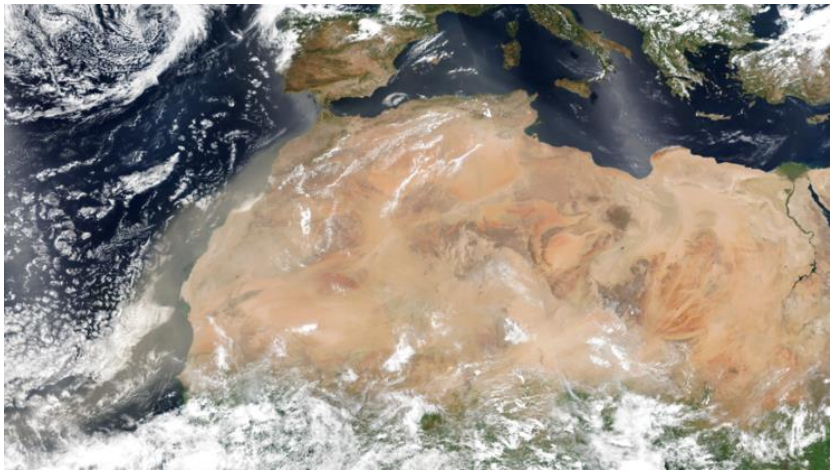


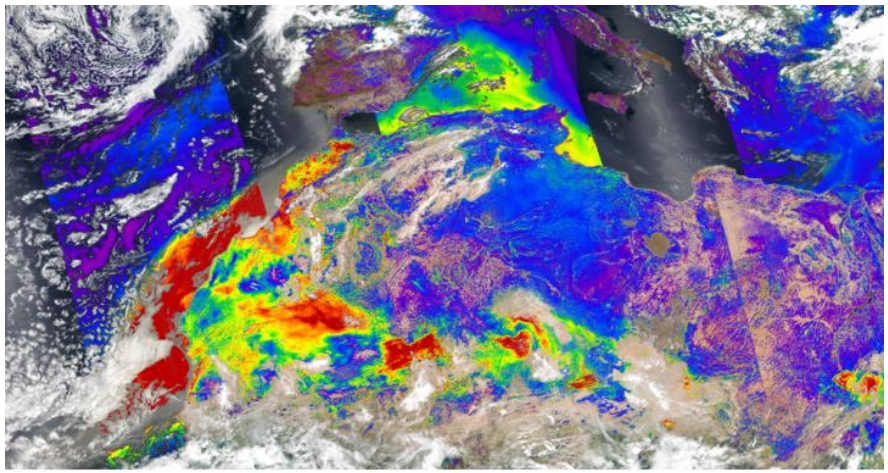




Future Plans/Improvements

- **Algorithm Improvements**
  - Add more aerosol models for over-land retrieval.
  - Update retrieval over bright surface to avoid discontinuity between ocean and land.

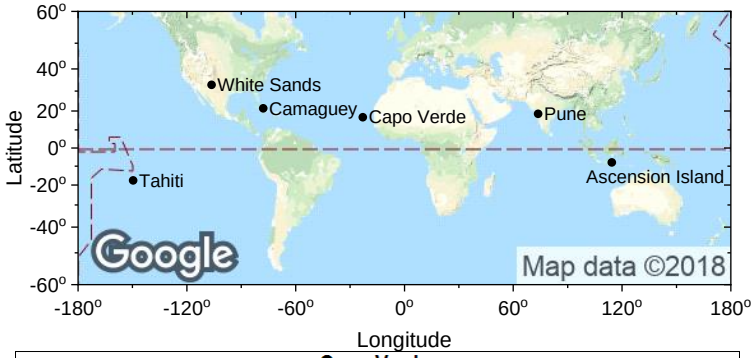


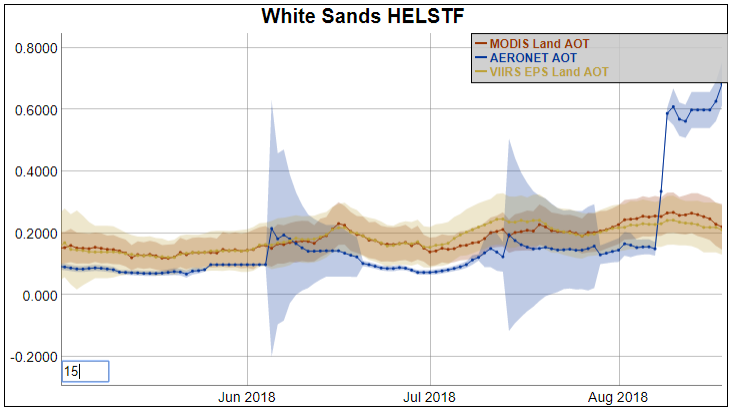


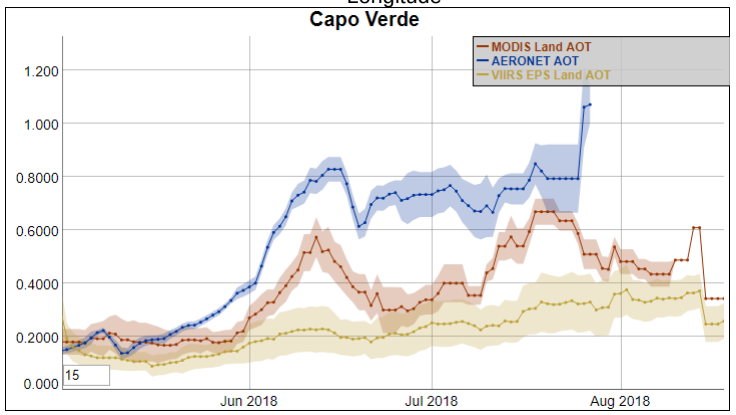
- **Reprocessing Plans/Status**
  - Reprocessed S-NPP VIIRS AOD with EPS algorithm for 2015 as a demonstration.
  - EPS AOD algorithm is mature and ready for re-processing more years once dedicated hardware resources are in place. Will use code with updates to record expanded version information.

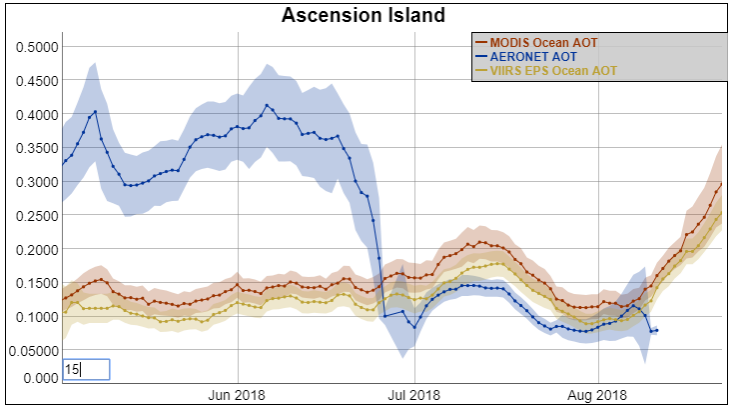
Future Plans/Improvements

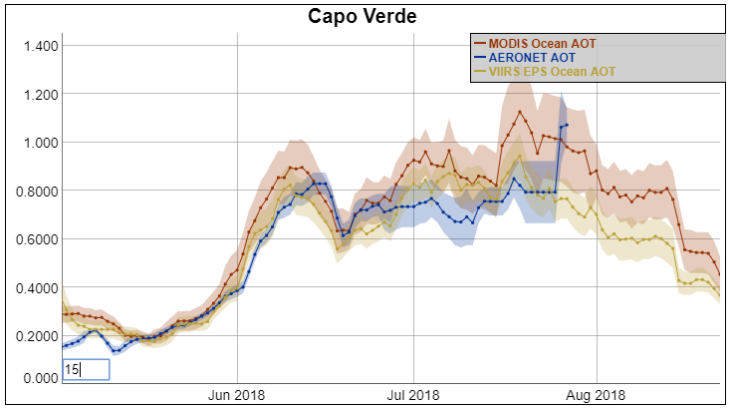
- **Long Term Monitoring**
  - Website: https://www.star.nesdis.noaa.gov/smcd/emb/viirs_aerosol/evaluation_ltm.php











AOD Summary

- Evaluation of S-NPP and NOAA-20 AOD with AERONET data shows the products meet requirements.
- NOAA-20 AOD is provisional pending LUT update.
- No significant risks have been identified once NOAA-20 LUT is implemented.
- Several algorithm updates are planned in FY19, including revised internal tests of ice and heavy aerosol.

APPLICATION OF VIIRS AOD FOR AIR QUALITY

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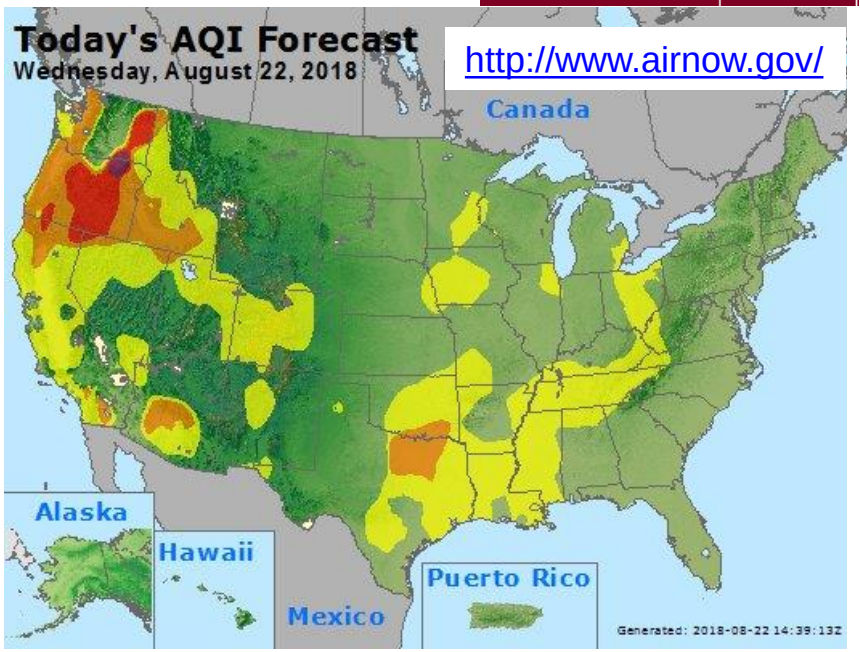
Ambient Air Quality Forecasting in the U.S.

- **State, local, and tribal government agencies** issue air quality forecasts to protect the public from the adverse health effects of **criteria pollutants**
  - O_3, $PM_{2.5}$, PM_{10} most commonly forecasted pollutants in the U.S.
- Forecasts typically issued by mid-afternoon (~3:00 PM), valid for the **next day**
  - Allows for lead time to communicate with public, local governments, businesses, schools in case of poor air quality forecast
- Forecasts communicated using the color-coded **Air Quality Index (AQI)**
  - Forecasts available on the **AirNow** national website, also state/local websites

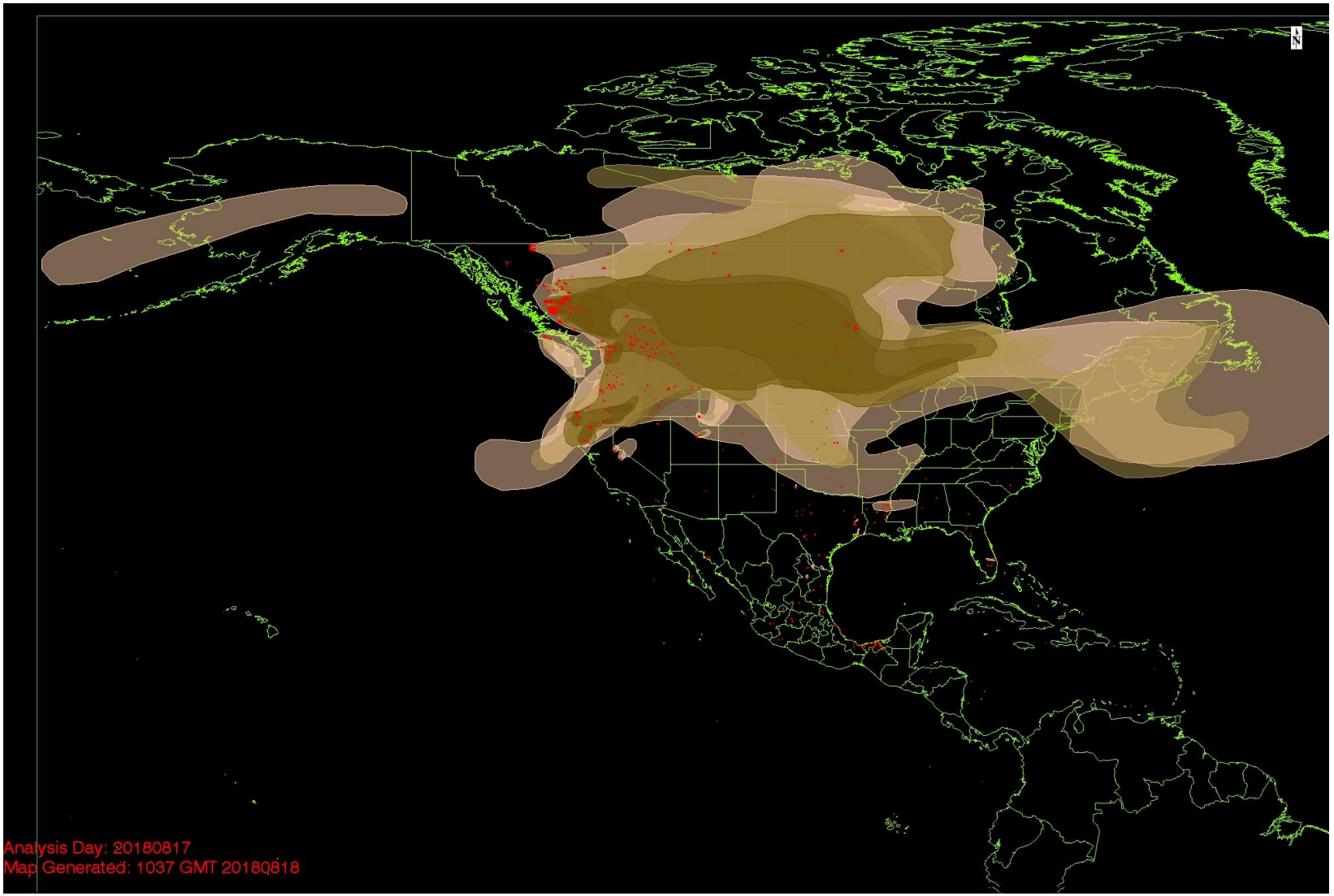
Good	0 to 50
Moderate	51 to 100
Unhealthy for Sensitive Groups	101 to 150
Unhealthy	151 to 200
Very Unhealthy	201 to 300
Hazardous	301 to 500



Wildfires are a Threat to Air Quality

- Emissions plumes from large wildfires contain:
  - Primary $PM_{2.5}$ and PM_{10} (smoke aerosols)
  - Nitrogen oxides (NO_x) and volatile organic compounds (VOCs): precursors for secondary formation of O_3 and $PM_{2.5}$
- Wildfires are becoming larger, more intense, and more frequent
  - Impact air quality **locally**, in vicinity of the fire
- Wildfire emissions plumes can be lofted above the boundary layer and remain relatively intact while traveling long distances, often hundreds of km
  - If the wildfire plume mixes to the surface **downwind**, it can substantially increase ambient O_3 and $PM_{2.5}$
- **Huge wildfires in western U.S. and Canada have been deteriorating local and downwind air quality across the CONUS in August 2018!**
  - **Example: week of Aug 13-17, 2018**

NOAA HMS Analysis: Aug 14-17, 2018



Smoke Transport in the News, Aug 16-17
Washington Post newspaper

Capital Weather Gang

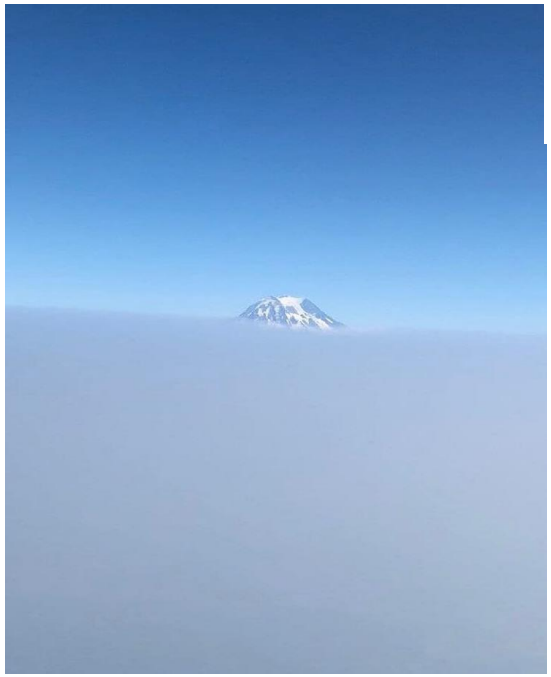
Smoke from California's wildfires is reaching Washington and Baltimore

By **Jason Samenow**, Weather editor
August 16

Lest anyone living in the D.C. area think Western wildfires are a problem 3,000 miles away, they might take a whiff of the air in their own backyard. Yes, high-altitude winds have carried the smoke across the country into the Mid-Atlantic region.

"I walked outside earlier and definitely smelled wildfire smoke," tweeted @annikaep from downtown Washington on Wednesday.

Capital Weather Gang readers queried on Twitter reported smelling smoke all over the region.



Capital Weather Gang

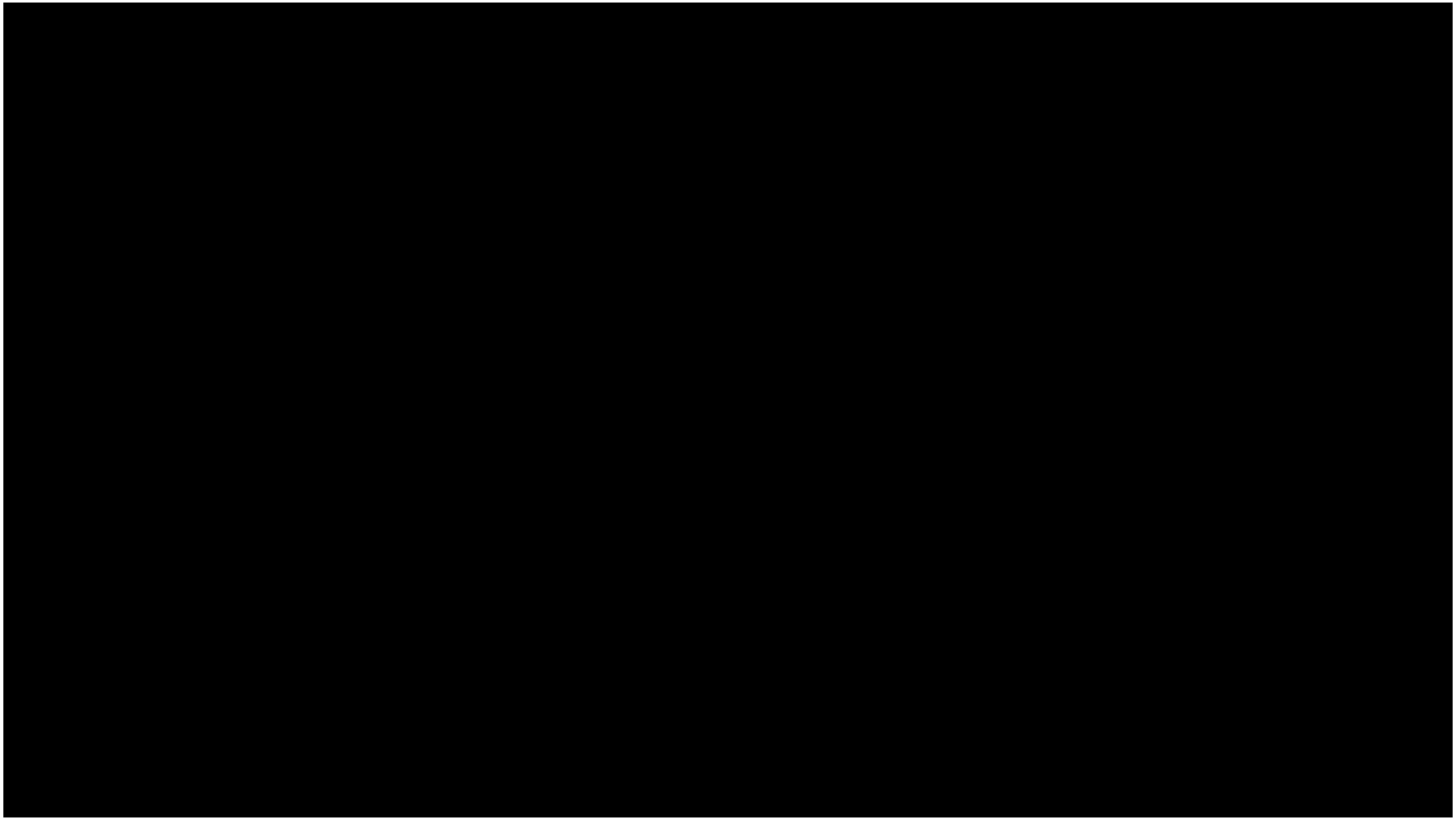
Mount Rainier looked like an iceberg floating in a sea of smoke earlier this week

By **Kathryn Prociv**
August 17

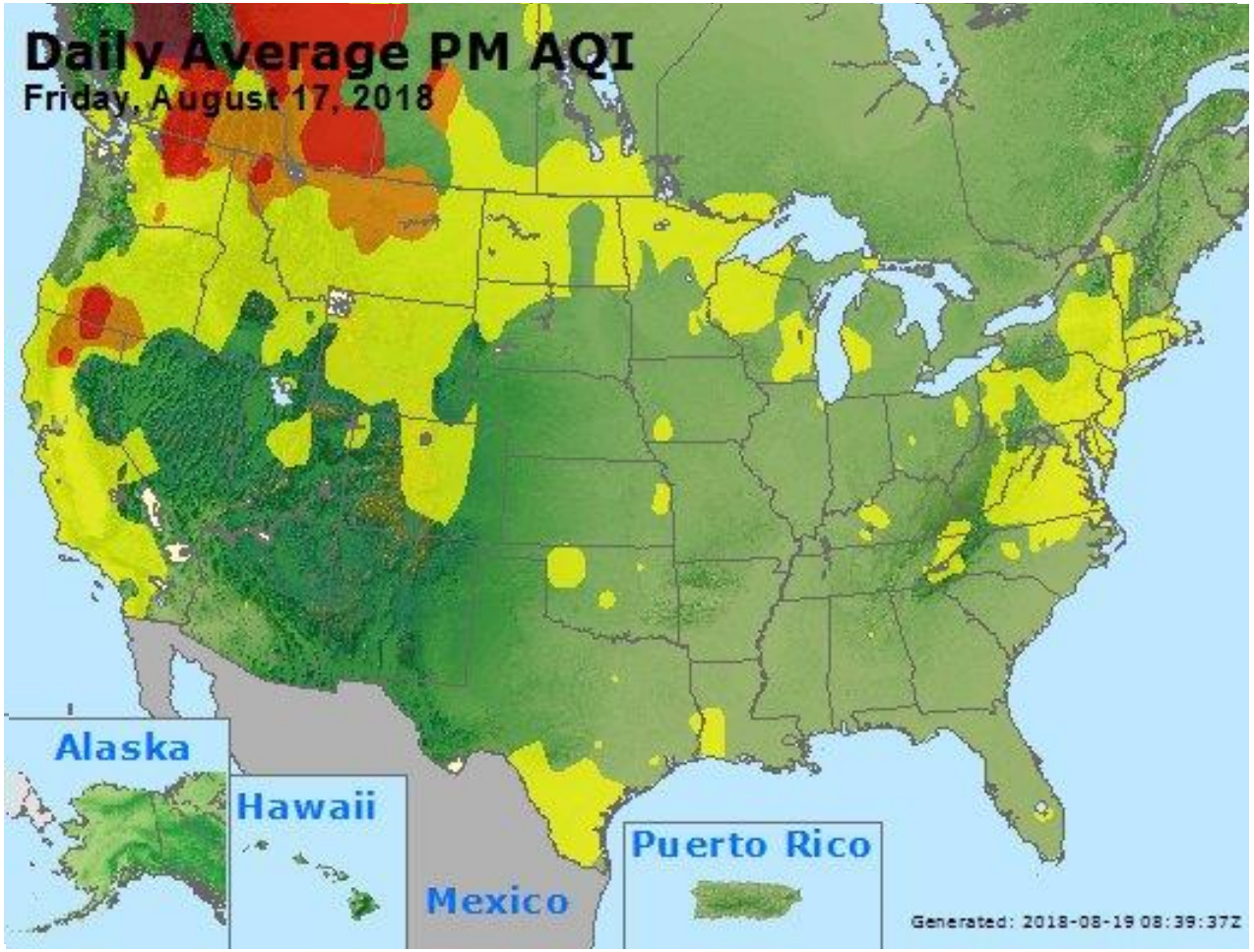
Capital Weather Gang

Wildfire smoke is choking Seattle, obscuring the view and blocking out the sun

Video of Thick Smoke on the Ground in British Columbia, Aug 17

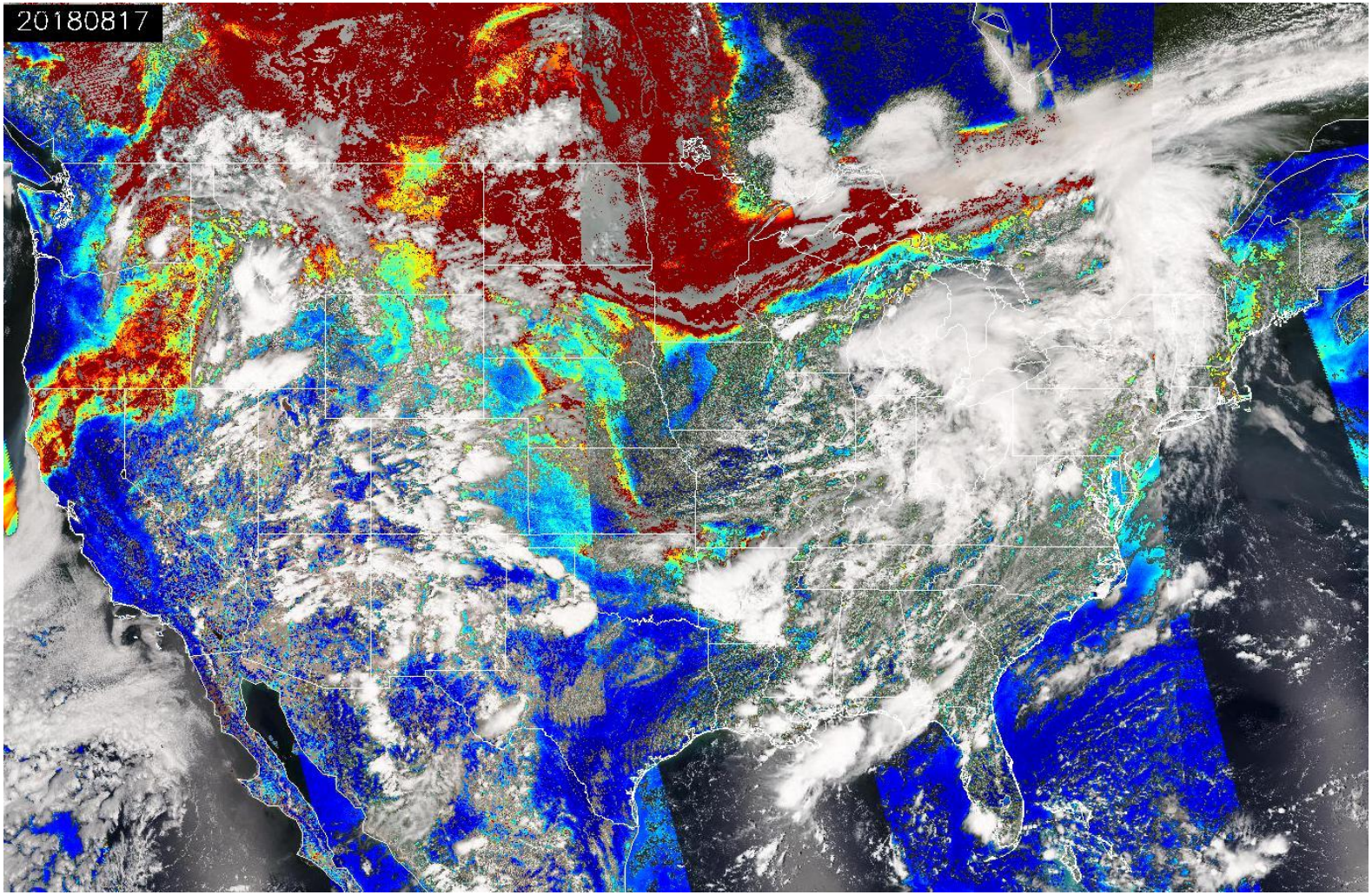


Observed Daily $PM_{2.5}$ Air Quality: Aug 14-17

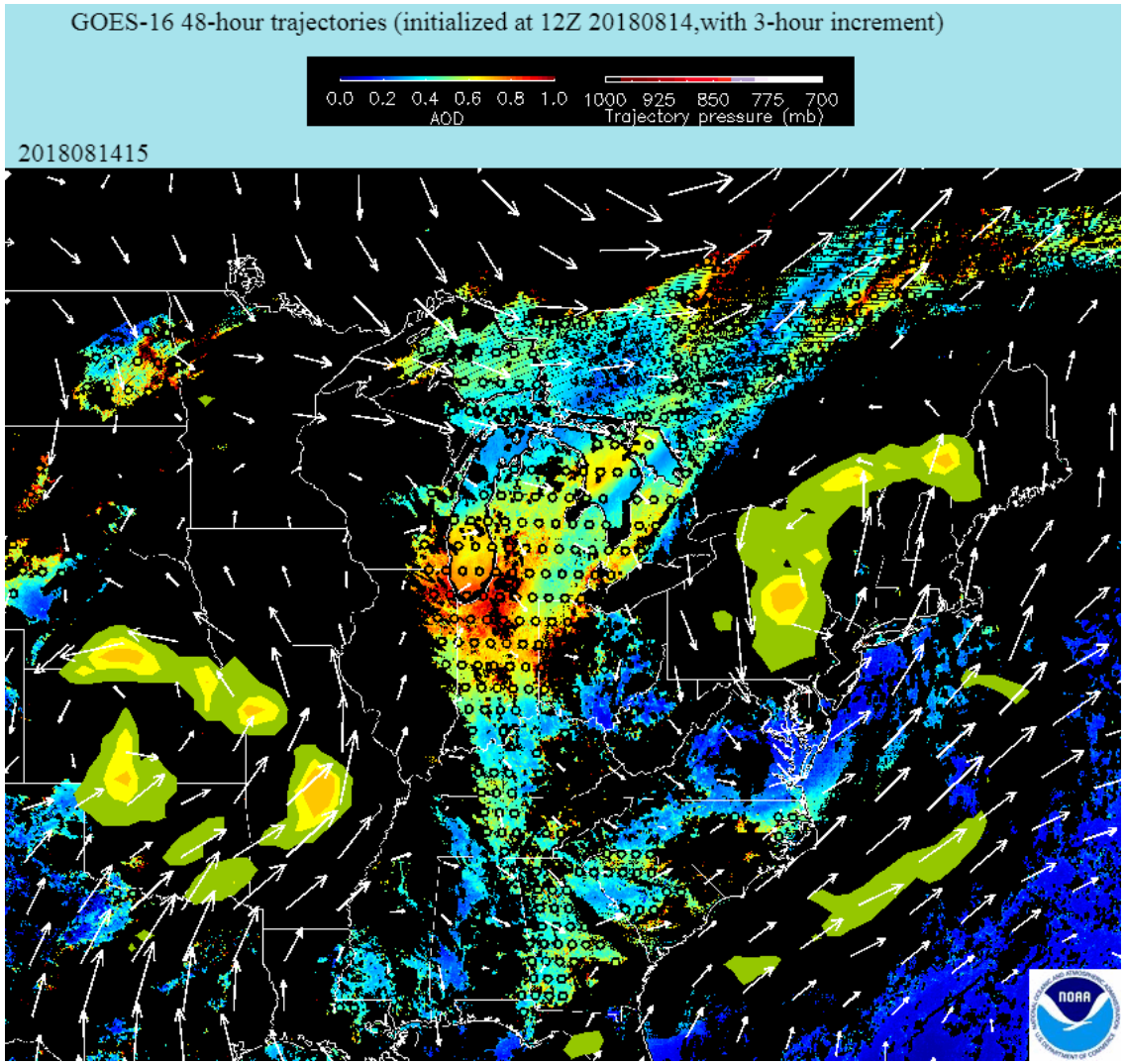


Good	0 to 50
Moderate	51 to 100
Unhealthy for Sensitive Groups	101 to 150
Unhealthy	151 to 200
Very Unhealthy	201 to 300
Hazardous	301 to 500

VIIRS SNPP RGB/AOT Captures Smoke Plumes: Aug 14-17



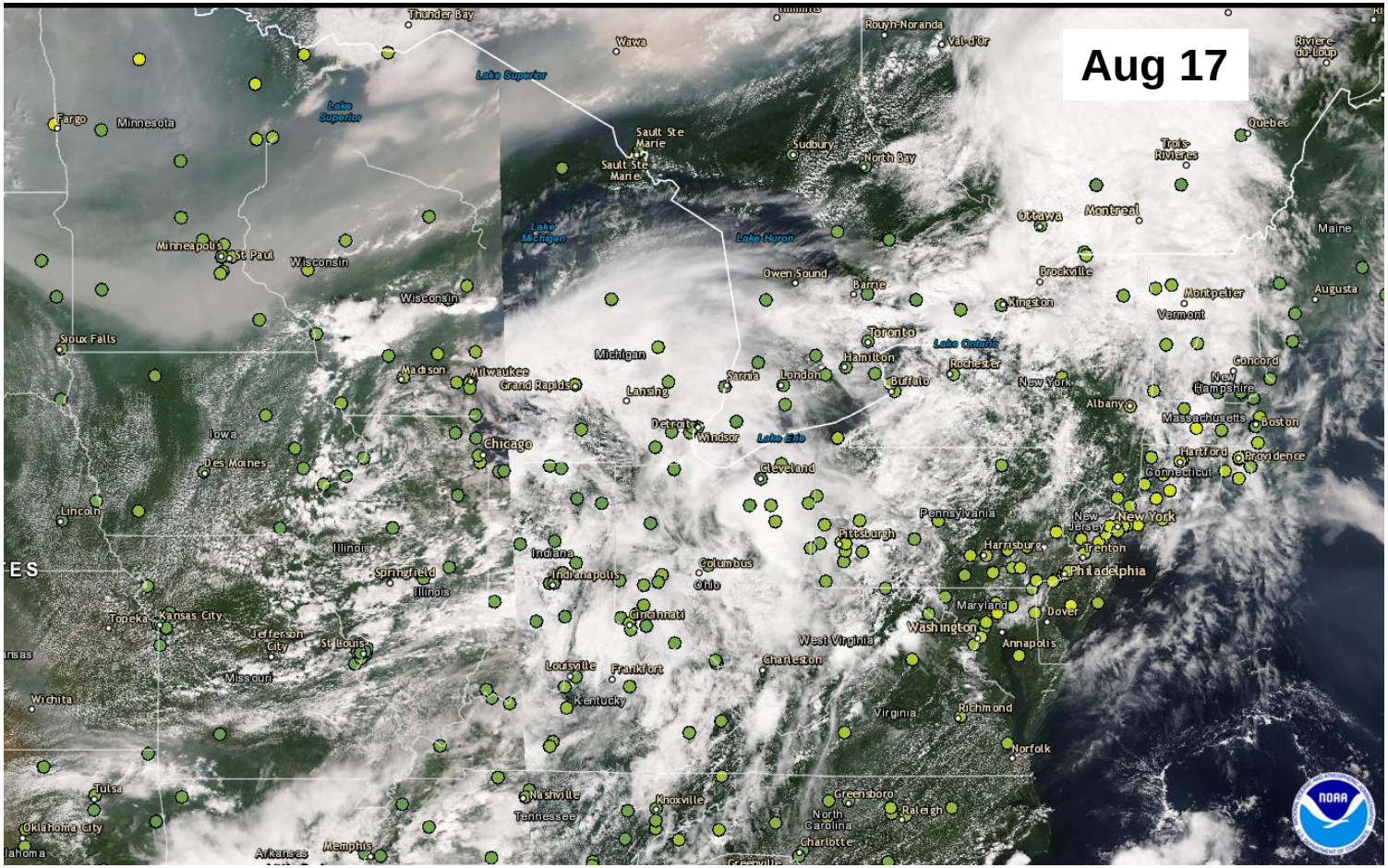
Where is the Smoke in the Great Lakes on Aug 14 Going to be on Aug 15?



Forecasting $PM_{2.5}$ in Mid-Atlantic

- Trajectories indicate 48-hr forward motion of aerosol plumes, vertically and horizontally
- Areas of high ABI AOD (>0.4) used as starting locations
- Trajectories initialized at 50, 100, 150, and 200 mb above surface
- Trajectories initialized with NAM 12Z run, plotted in 3-hr increments:
  - Pink: near surface
  - White: away from surface
- 850 mb wind vectors (white)
- 3-hr accumulated precipitation (yellow)

Smoke Moves into Mid-Atlantic: Aug 15-17



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VIIRS NOAA-20 RGB and daily $PM_{2.5}$ observed ground-level concentrations from *AerosolWatch* website

VIIRS Data Supports Forecasting and Post-Analysis

- Satellite AOD essential for identifying smoke plume transport
  - Gives forecasters a heads-up when smoke may be heading toward forecast area
  - Use in conjunction with surface $PM_{2.5}$ measurements to determine when smoke is impacting surface air quality
- 48-hour aerosol trajectories critical tool for identifying when smoke will reach surface in forecast area (affecting local ambient $PM_{2.5}$ and O_3)
- New *AerosolWatch* website designed for operational users
  - Includes VIIRS aerosol imagery from **SNPP and NOAA-20**
- VIIRS AOD, smoke/dust mask, and aerosol trajectories critical for post-analysis, including Exceptional Event demonstrations
  - Petitions by states to U.S. EPA, showing exceedance of NAAQS was not due to local conditions, rather caused by “exceptional event”
  - Example: May 25-26 O_3 exceedances in CT, NJ, PA due to smoke transport from Ft McMurray wildfire in Alberta, Canada